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EVALUATION OF DEGRADATION STATUS FOR THREE CAVES IN ROMANIA

EVALUAREA STATUSULUI DEGRADĂRII PENTRU TREI PEȘTERI DIN ROMÂNIA

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Abstract: Cave ecosystem research has known a growing interest in the last years. Nonetheless there is more to be found out about underground world of caves. The difficulty of access and rapid change of conditions that might occur in many cases, among other factors make the survey of this kind of environment a hard task to accomplish. This paper applies on three caves from Romania, the attempts made by other authors in assessing the degree of cave environment degradation. Method used combines characteristics of both subterranean and supraterranen domains associated to caves.

Key-words: *cave, cave degradation.*
Cuvinte cheie: *peșteră, degradarea peșterilor.*

I. INTRODUCTION

"Cave environments are characterized by possessing specialized fauna living in high environmental stability with limited food conditions. The fauna is highly vulnerable to impacts, because this condition can frequently be easily altered. Moreover, environmental determines the biodiversity patterns of caves remain poorly understood and protected" (Souza et al., 2015). This quote presents, in a short and clear form, the importance of keeping the fine equilibrium needed for a cave ecosystem to survive in good conditions.

The main cause for degradation of underground habitats consist of certain actions of human society with negative impact on landscape evolution, vegetation and climate (Negrea, 2003).

To keep or restore the equilibrium is necessary to determine the cause of degradation and its extent. Attempts in the regard of determining the mentioned causes were made by van Beynen and his collaborators when they introduced karst disturbance index (van Beynen&Townsend, 2005; van Beynen et al, 2007). This index, that takes into account anthropogenic change, is more useful for supraterranean karst areas, although it is considering also some of the underground characteristics of karst.

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The much recent work of Donato et al, 2014 and Souza et al., 2015, consider in more detail the state of a cave, calculating Cave Conservation Index (CCI) and Cave Conservation Priority Index (CCPi).

Using data from the last two mentioned papers, Avram et al. (2017) tried to assess cave degradation in five caves from Romania. In this paper it will be applied the latter model for three caves from Romania (Fig. 1).

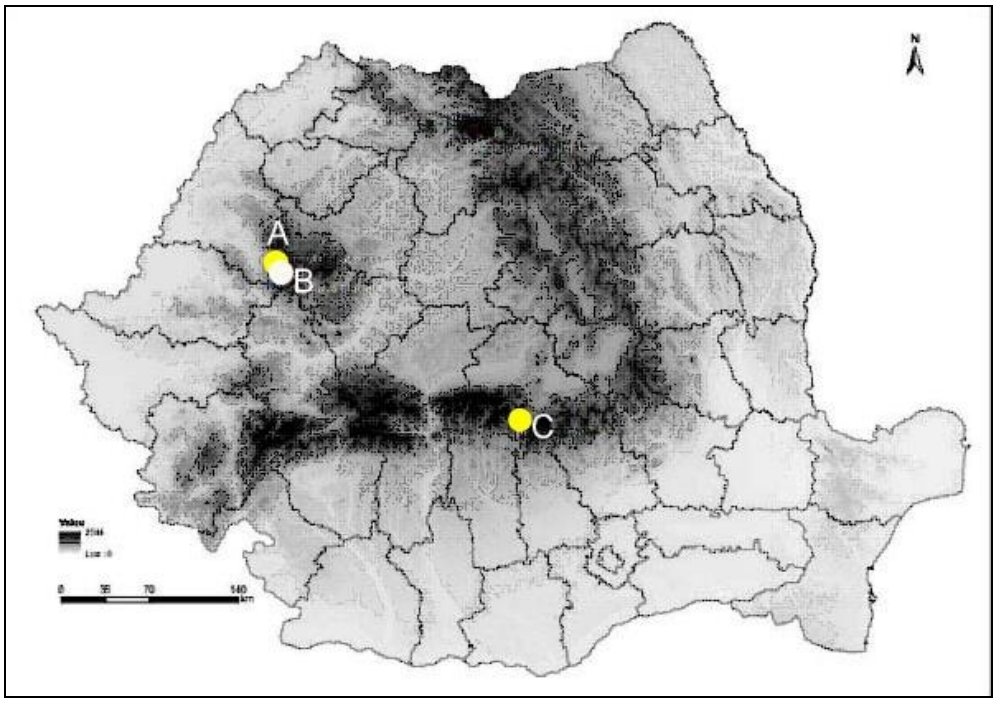

Fig. 1. Location on the map of Romania for the studied caves; A-Avenul din Șesuri, B-Gheţarul Scărișoara, C-Dâmbovicioara

II. DATA AND METHODS

The degradation of the ecosystems appears when the capacity to provide services is reduced (Millennium Ecosystem Assessment, 2005). Ecosystem services, according to Defra, 2007, are the wide range of benefits that a healthy natural environment provides to people, either directly or indirectly (see Table 1).

The ecosystem can, in general, be defined in the simplest terms as a unit of organisms (animals, plants, microorganisms, ihumans) and their physical environment. Living and non-living components work together as an interdependent system. If one party is affected, it can impact the entire system (Defra, 2007). The boundaries of the area with impact on the caves ecosystem are found beyond the cavity space into which the surface streams are lost underground and from which groundwater comes to the surface (Culver&White, 2012).

Table no. 1. Example of ecosystem services provided by caves
(Millennium Ecosystem Assessment, 2005**)**

Supply services		Conservation of genetic local resources
		Source of manure
		A source of food in some areas
Regulating services		Regulating the flow of water
		Water filtration and purification
		Fixing mineral carbon in network
		Role in reducing insect pests
Cultural services	Recreationand tourism	Visiting caves
	Aesthetic values	Concretion formations or erosion
	Scientific value	The fossil formations presence which can provide information about past climatic evolution
	Education	Educational visits made by students

All the ideas above show the presence of an expanded territory that can influence the environmental degradation and consequently the cave ecosystem services. The services that regularize water flow are affected or eliminated by human activities such quarrying or mining. Supply services (source of manure) and regulating services (role in reducing insect pests) are negatively influenced by modifying the conditions in the vicinity of the cave through deforestation, replacing old autochthonous tree species with new species, reducing the diversity of herbaceous plant species, creation of artificial lakes (Negrea&Negrea, 2004).

Because of the microorganism's dynamics the biofilm appears and the changing in the natural balance of the organic matter dissolved in water attracts the decrease of the filtering services provided by the caves. Such microorganisms are the basis of food chain dominated by detritivore playing a key role in biological filtration. Adding physical and chemical processes taking part in the ecosystem service water filtration in caves, there is a pragmatic argument for the need to preserve groundwater ecosystems (Boulton, 2005).

The lack of vegetation and soil removal (karst rock desertification) is changing the coating amounts of water intake, nutrient, and sediment that can reach through the network of cracks in holes connecting the endokarst.

Wang et al. 2004 show how "karst rocky desertification" in southwestern China is accelerated by human activities like deforestation and animal grazing . The same situation was previously mentioned in mediterranean region too by Williams (1993) and Urich (2000) who estimates, for temperate areas, the increase of water runoff by 35%, which further leads to removing a more significant quantity of soil on slopes.

Donato et al. (2014), to calculate the Rapid Assessment Protocol of cave environmental (RAPcei) consider many of the causes that leads to habitat degradation and to the decrease of ecosystem services. Avram et al. (2017) add one type of environmental impact (i.e. construction of human origin) rising the total maximum score for RAPcei from 100 to 110; keeping the initial classification but

modifying the score interval for the last of the six cave categories, the latter author separate caves based on RAPcei in:

a. Intact caves (I) –the score is ≤ 7 points.
b. Stable caves (S) –the score is between 8 -34 points.
c. Vulnerable caves (VU) – the score is between 35-61 points.
d. Endangered caves (EN) –the score is between 62-84 points.
e. Critically endangered caves (CR) –score is between 85-109 points.
f. Extinct caves (EX) –the score is 110 points.

Using the same criteria, RAPcei values, cave ecosystem status is determied as seen in Table no. 2.

Table no. 2. Ecosystem status based on RAPcei values (Avram et al., 2017)

Ecosystem status	Natural cave	Semi-degraded cave	Degraded cave
Values of Rap-cei	0-34%	35-84%	85%-110%

The needed data for the indicators used to establish the degradation stage of cave ecosystems were obtained from:

• Speological literature (presence of different invetebrates or vertebrate species, plans and maps of the caves).

• Hydro-geological literature (the dynamic of the water level in karstic holes).

• Topographical maps and ortophotmosaics, (assessment of deforestation level above the caves, appreciation distance from the nearest roads or places, quarries to caves, identifying where streams entering inside the cave, crossing one or more localities).

• Management plans of national and nature parks from Romania,

The values for deforestation above the caves and anthropic modification of natural environment (D) were determined using AutoCAD. For the calculation of D a circle was drawn with diameter equal to the maximum length of cave projection on a ortophotomosaic. Center of the circle was set in the middle of this line of maximum length.

To appreciate the magnitude of deforestation, the presence of vegetation as seen on recent orthophotomosaic was compared to presence of vegetation on older topographic maps. When deforestation was observed on a surface of at least 90% of the drawn circle the score was considered 10 points,between 65% and 90% the score was 6 points, between 65%-40% 4 points, between 40%-15% 2 points.

Estimation of the influence of anthropic impact (EC) was realised in a similar manner, circles with radius of 1000m, 1500m and 2000m were drawn from the same center point as for estimation of D.The purpose or this was to see the distances from te caves to road infrastructure, human settlements, mining activities.

Table no. 3. Rapid assessment protocol of environmental impact related to caves-RAP-cei (Avram et al., 2017 modified after Donato et al., 2014)

Activity(ies) causing impact		
( ) Mining	( ) Agriculture/Ranching	( ) Tourism/disorderly visitation
( ) Damming	( ) Urbanization	( ) Engineering work

Score refers to the magnitude of the impact, which indicates the severity of the impact on the environment. The magnitude canbe of four types:
1 – Threats to natural resources is negligible regarding its depletion and the environment and community degradation, beingreversible in a short term (up to 1 year); add 2 points.
2 – The use of natural resources is considerable but the depletion of the natural reserves is not possible, being the degradation of the environment and the community reversible in the medium term (1 to 10 years), if immediate actions take place; add 4 points.
3 - The use of natural resources is considerable and the depletion of the natural reserves is possible, being the degradation ofthe environment and the community reversible in the long term (10 to 50 years), if immediate actions take place; add 6 points.
4 – When the action caused the scarcity of natural resources, and the degradation of the environment and the community
does not have many chances of reversibility; add 10 points.
5 – If there are more than one component to be evaluated in each indicator, consider the sum of the scores, for values below10 and/or give the highest score (10) if the sum of values is greater than 10.

Type of impact	**Symbol**	**Estimated Score**	**Achieved Score**
Complete destruction of the cave (in this case, there is no need of continuing analysingthe impacts, scoring closes here).	CD	0 / 110	
Partial destruction of the cave.	PD	0 / 2 / 4 / 6 / 10	
Changes in water dynamics: lowering of the aquifer; partial or complete flooding; drying of karstic lakes and ponds; destruction of cargo areas; obstruction of ducts and consequent flooding or drying.	WD	0 / 2 / 4 / 6 / 10	
Karst changes: cracks, detachments, broken speleothems, collapse of karstic structures.	KC	0 / 2 / 4 / 6 / 10	
Alterations of subsurface soil: trampling of delicate formations, pavement compaction.	AS	0 / 2 / 4 / 6 / 10	
Sound pollution: acoustic overlap and vibration.	SP	0 / 2 / 4 / 6 / 10	
Pollution of groundwater: eutrophication, presence of pollutants (i.e. oil, suds)	GP	0 / 2 / 4 / 6 / 10	
Natural vegetation deforestation by fire or other human activities, reduction of organic resources, increase of exotic species, spread of pollutants, soil acidification.	D	0 / 2 / 4 / 6 / 10	
Masonry work: lighting, walkways, microclimatic changes.	M	0 / 2 / 4 / 6 / 10	
Disorderly visitation/vandalism: garbage, graffiti, and other types of vandalism.	V	0 / 2 / 4 / 6 / 10	
Range of impact, considering the most impactful action: If there is no impact – add 0 points. If the impact is local – add 5 more points. If the impact is regional – add 10 more points. Note: Local – when the effect is restricted to the site of action; Regional – when the effect is spread over an area beyond the immediate vicinity of where the action takes place.	R	0 / 5 / 10	
Presence of buildings or environmental changes (such crosroads, urban core, mining, agriculture/ranching, etc.) nearthe cave area or close to streams of water passing through caves:>2000;1500-2000;1500-1000;<1000meters	EC	0/3/7/10	

III. RESULTS AND DISCUSSIONS

The first of the three caves is ”Avenul din Șesuri”, also known under the name of "1 May Cave", the day of the first exploration in 1950 (Bleahu et al., 1976). It is part of a karst complex which also includes the Ghețarul de la Scărișoara, Izbucul Poliței and Pojarul Poliței (Damm et al., 1999). It represents a complex underground network carved in limestone, which totalizes 4270 m of gallery and wells having a level difference of 219 m (speologie.org).

The entrance has an oval shape of 6/3 m and is located at 1120 m absolute altitude (Goran, 1982). This cave used to be a ponor-cave, created by a river, no longer active today, a typical „drawdown vadose cave” (Damm et al., 1999). Bleahu et al. (1976) mentions troglobiont *Typhloiulus serbani* as the only described fauna. Fossil remains of *Rupcapra rupicapra* and *Bison priscus* were found in sediments from the initial descending segment of the shaft cave.

The second cave, Peștera Ghețarul Scărișoara, is one of the biggest ice caves in the Apuseni Mountain. It is considered a show cave and one of the natural wonders of Romania. The cave found in Triasic limestone, at an altitude of 1,165 metres above sea level with a total length of around 700 m (Bleahu et al., 1976). The entrance shaft 60 m in diameter, in some places and 48 m deep (Orghidan, 1984) has a thick layer of snow all year round. Tourists are allowed to visit only the entrance shaft and the circular area found at its base (around 100m diameter) separated into Sala Mare (Big Hall) and Biserica (Church) where ice stalagmites are forming.

The glacier is over 4000 years old, has a volume of 75,000 cubic metres and an upper surface of 3,000 square meters. The temperature is up to +1°C during summer and down to -7°C during winter. In the part for tourists the average temperature is around 0°C. To avoid disturbing bats that live in the ice cave, artificial lights were rearranged (Layman Report, 2014). Exceting presence of bats fauna is scarce, the coleopter *Pholeuon prozerpinae glaciale* being the most significant apearence.

Both Avenul din Șesuri and Ghețarul Scărișoara caves were developed folowing the dip of the limestone layers (Damm et al., 1999).

In Figure 2 can be seen how while Avenul din Șesuri cave is not covered for the entire length by forest (southern quarter of it being covered with pasture), Ghețarul Scărișoara cave is entirely covered.

Buildings are present close to both caves, less than 150m in some parts, which is a very short distance compared with 1000m, the distance needed for EC (environmental changes) to have the score of 10 points.

Ghețarul Scărișoara being a show cave, masonry works (stairs, electric illumination) are present. The visitors induce microclimate changes which accelerates the melting of the ice deposit and in this way data of great value for palaeoclimatology are lost (Negrea, 2003).

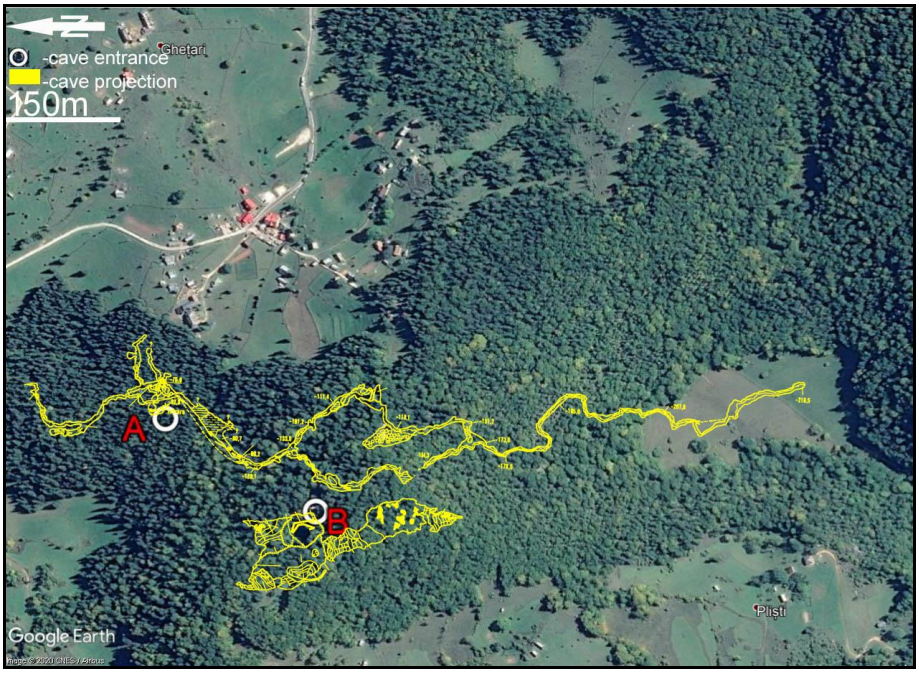

Fig. 2. Avenul din Șesuri cave projection (A) and Gheţarul Scărișoara cave projection (B) overlaid on ortophotomosaic

Fig. 3. Dâmbovicioara cave projection (C) overlaid on ortophotomosaic

The third cave, Dâmbovicioara Cave, is located in the southern side of Piatra Craiului Mountains. Although a rather small cave, it has an impressive, varied karst relief. It's a relatively warm cave with a temperature between 10–12 degrees, with moderate humidity; the age of the limestone that host the cave is Jurasic (Bleahu et al., 1976). It has a total length of 555 meters and a level difference of +33m (Giurgiu&Dobrescu, 1980). The cave can be visited with ease for the first 150m, having approximately 3-4 meters in width and 4-5 meters in height (Orghidan, 1984). The fauna is scarce and no troglobiont species were mentioned (Bleahu et al., 1976).

D (deforestation) score is 0 for Dâmbovicioara cave because the circle that encompases the cave is completely covered by forest. Buildings are present begining with a distance smaller than 500m, and cave entrance is beside the road. These conditions justify the score of 10 points for the impact of environmental changes. Since 1980 electric lighting was introduce in this cave. The few concretion formed in the cave were deteriorated by visitors. The lack of fauna is caused mainly by the visitors presence and interaction with the interior of the cave.

The values for the types of impact present in Table no. 3, for the three caves studied are shown in Table no. 4.

Table no. 4. Impact type present in the three analyzed caves

Cave name	Location	Impact type											Total
		PD	WD	KC	AS	SP	GP	D	M	V	R	EC	
Avenul din Șesuri	Gârda de Sus	0	0	0	2	0	0	4	0	2	5	10	21
Dâmbovicioara	Dâmbo vicioara	6	0	6	4	0	0	0	6	6	5	10	41
Gheţarul de la Scărişoara	Gârda de Sus	2	0	4	2	0	2	0	6	4	5	10	35

IV. CONCLUSIONS

Applying the methodology that determine the environmental impact for a cave, the three studied caves can be set in the next two categories (based on Rapcei score:

- Stable caves (S) - Avenul din Șesuri with a score of 21 points;
- Vulnerable caves (VU) - Dâmbovicioara Cave with 41 points and Gheţarul de la Scărişoara Cave with 35 points.

The ecosystem for stable caves (S) is considered to be in the natural state while for those in vulnerable stage (VU) - in a semi-degrade state. The semi-degraded ecosystem state of the two above mentioned caves is the effect mainly of to partial masonry and anthropogenic environmental changes.

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